PART 14

EXAMINATION IN THE INTENSIVE CARE UNIT

CHAPTER 70

Examination of Patients in the Intensive Care Unit

KEY TEACHING POINTS

- Careful examination of the intensive care unit (ICU) patient remains essential because it is the only way (among many examples) to detect the purulence around intravenous lines, the warmth of an infected joint, the purpuric skin lesions of septic emboli, the wheezing of bronchospasm, the neck stiffness of meningitis, or the absent doll's-eyes of cerebellar stroke.
- The modified early warning score accurately identifies a patient's risk of hospital mortality.
- In patients with shock, several findings have diagnostic value. For example, the *absence* of warm hands *decreases* the probability of septic shock, the *presence* of elevated venous pressure and crackles *increases* the probability of cardiogenic shock, and the *presence* of a pulse pressure increment after passive leg elevation *increases* the probability of hypovolemic shock.
- The findings of cool limbs, prolonged capillary refill times, and mottling of the limbs (i.e., blotchy or lacelike pattern of dusky discoloration) all increase the probability of reduced cardiac output and a worse prognosis.

I. INTRODUCTION

The traditional physical examination meets many challenges in the ICU. First, it must compete with legions of additional sensory information, including continuous telemetry of vital signs, heart rhythm displays, ventilator parameters, and flow sheets of urine output, mental status, and intravenous medications. Second, there are many barriers to traditional inspection, palpation, percussion, and auscultation: central lines and dressings conceal the neck veins, anasarca limits normal palpation, and cardiac leads and ventilator noise obscure heart and lung sounds. Even so, careful examination has value in the ICU patient because it is the only

TABLE 70.1 Modified Early Warning Score*

Points	3	2	1	0	1	2	3
Systolic blood pressure (mm Hg)	<70	71-80	81-100	101-199	—	≥200	—
Heart rate (beats/min)	—	<40	41-50	51-100	101-110	111-129	≥130
Respiratory rate (breaths/min)	—	<9	—	9-14	15-20	21-29	≥30
Temperature (°C)	—	<35	—	35.0-38.4	—	≥38.5	—
Neurologic score	—	—	—	Alert	Voice	Pain	Unresponsive

*Based upon reference 1.

way, among many examples, to detect the purulence around intravenous lines, the warmth of an infected joint, the purpuric skin lesions of septic emboli, the wheezing of bronchospasm, the neck stiffness of meningitis, or the absent doll's eyes of cerebellar stroke.

This chapter brings together both those aspects of physical examination that are relevant to critically ill patients already discussed in previous chapters and presents several findings not previously reviewed.

II. THE FINDINGS

Other chapters in this book discuss vital signs (Chapters 15 to 20), asynchronous breathing (Chapter 19), anisocoria (Chapter 21), assessments of peripheral perfusion (Chapter 54), and neck stiffness (Chapters 26 and 67). This chapter reviews these findings and introduces additional findings: the modified early warning score, passive leg elevation in assessments of hypovolemia, and the diagnosis of septic and cardiogenic shock.

A. MODIFIED EARLY WARNING SCORE (TABLE 70.1)

Developed in 2001 by Subbe,[1] who simplified previous scores used in critically ill surgical patients, the **modified early warning score** relies on measurements of four vital signs (systolic blood pressure, heart rate, respiratory rate, and temperature) and mental status (using the acronym **AVPU**, which stands for Alert, responsive to Voice, responsive to Pain, or Unresponsive). In Table 70.1, normal parameters are shaded in gray. The greater the deviation from these normal measurements in either direction, the greater the score and presumed risk of hospital death. Patients at highest risk may benefit from observation in an ICU.

B. ASSESSMENT OF PERIPHERAL PERFUSION IN THE ICU

There are three findings of peripheral perfusion in ICU patients[2]: (1) temperature of limbs, which should reflect the volume of blood circulating in the most superficial vessels of the skin[3]; (2) capillary refill time (see Chapter 54); and (3) mottled skin, especially of the knees. Mottling describes a lacy purplish net-like discoloration of the skin, a sign indicating sluggish blood flow in dilated superficial postcapillary venules.[3]

C. PULSE PRESSURE CHANGES WITH PASSIVE LEG ELEVATION (HYPOVOLEMIA)

Critical care physicians have long sought ways to anticipate which patients with hypotension would benefit from intravascular saline infusions. Based on the

EBM BOX 70.1
*Examination of Patients in the Intensive Care Unit**

Finding (Reference)†	Sensitivity (%)	Specificity (%)	Likelihood Ratio‡ if Finding Is Present	Likelihood Ratio‡ if Finding Is Absent
Vital Signs				
Modified early warning score, predicting hospital mortality[4-8]				
0 points	2-18	39-77	**0.2**	—
≥ 5 points	22-62	79-97	**4.7**	—
Shock				
Detecting septic shock[9]				
Hands warm	88	67	2.7	**0.2**
Bounding pulses	64	73	2.4	0.5
Detecting cardiogenic shock[9]				
CVP >8 cm H_2O	82	79	**4.0**	**0.2**
Lung crackles	55	72	1.9	NS
CVP >8 cm H_2O and crackles	55	99	**56.4**	0.5
Detecting hypovolemic shock				
Pulse pressure increase ≥12% with passive leg elevation[10-13]	48-79	85-92	**4.8**	0.5

Continued

hypothesis that pulse pressure reflects stroke volume (see Chapter 17) and the idea that passive elevation of the patient's legs reversibly transfers blood from the legs to the thorax, clinicians have investigated whether changes in pulse pressure after passive leg elevation might predict volume responsiveness.

The methods of this test are not standardized, but the procedures used in the studies from EBM Box 70.1 are as follows: The clinician measures baseline blood pressure with the patient's legs horizontal on the bed.* After baseline measurements, the clinician lifts the patient's legs to a 45-degree angle (the trunk is now supine). Both the baseline and postelevation blood pressure measurements are measured (three of four studies used intra-arterial catheters) and multiple readings over 1 to 4 minutes in both positions are averaged (after leg elevation, changes in blood pressure usually appear within 1 minute). An increase in mean pulse pressure of at least 9% to 12% after elevating the legs is *test positive*. For example, if a patient's average

*The position of the trunk during baseline measurements was supine in two studies[11,13] and elevated at a 45-degree angle in two others.[10,12]

EBM BOX 70.1
Examination of Patients in the Intensive Care Unit—cont'd*

Finding (Reference)†	Sensitivity (%)	Specificity (%)	Likelihood Ratio‡ if Finding Is Present	Likelihood Ratio‡ if Finding Is Absent
Lungs				
Asynchronous breathing during COPD exacerbation, predicting intubation or death[14]	64	80	**3.2**	NS
Asymmetric breath sounds after intubation, detecting right mainstem bronchus intubation[15-17]	28-83	93-99	**18.8**	0.5
Absent breath sounds in patients with ARDS, detecting underlying pleural effusion[18]	42	90	**4.3**	0.6
Neurologic				
Anisocoria in patients with coma, detecting structural intracranial lesion[19]	39	96	**9.0**	0.6
Neck stiffness in patients with stroke, detecting hemorrhagic stroke[20-25]	16-48	81-98	**5.4**	0.7

*Diagnostic standard: For *septic shock,* blinded consensus diagnosis based on microbiologic and radiographic data acquired after onset of shock; for *cardiogenic shock,* evidence of acute ventricular dysfunction on echocardiography; for *hypovolemic shock,* 500-cc intravenous saline challenge produces ≥15% increase in aortic blood flow,[10,11] cardiac index,[12] or echocardiographic stroke volume [13]; for *structural lesion*, supratentorial and subtentorial lesions with gross anatomical abnormality, including cerebrovascular disease, intracranial hematoma, tumor, and contusion.
†Definition of findings: For *modified early warning score*, see Table 70.1; for *hands warm* and *bounding pulses* (septic shock), hands are warmer and pulses more bounding in the patient than in the examiner; for *pulse pressure increase* (after passive leg elevation), increase in pulse pressure of at least 9%,[13] 11%,[12] or 12%[10,11]; for *asynchronous breathing,* see Chapter 19 and Fig 19.2.
‡Likelihood ratio (LR) if finding present = positive LR; LR if finding absent = negative LR.
ARDS, Acute respiratory distress syndrome; *CVP,* central venous pressure; *COPD,* chronic obstructive pulmonary disease; *NS,* not significant.
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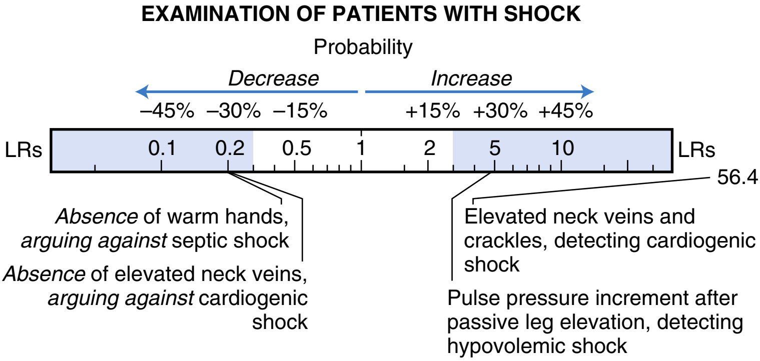

blood pressure is 100/54 at baseline and 114/61 after leg elevation, the pulse pressure has risen from 46 mm Hg to 53 mm Hg, an increase of 7/46 mm Hg or 15%.

Patients with deep venous thrombosis of either leg were excluded from these trials.

III. CLINICAL SIGNIFICANCE

A. MODIFIED EARLY WARNING SCORE

In five studies of almost 3500 patients with acute medical illness (i.e., trauma excluded), a modified early warning score of 5 or more predicts increased risk of hospital death (likelihood ratio [LR] = 4.7, EBM Box 70.1; in these studies, overall mortality was 4% to 15%): Patients with a score of 5 or more may benefit from more intensive monitoring. A score of 0 (i.e., all parameters within the gray-shaded area of Table 70.1) predicts a reduced risk of death (LR = 0.2).

B. SEPTIC SHOCK AND CARDIOGENIC SHOCK

In one study of 68 hospitalized patients with acute shock (systolic blood pressure less than 90 mm Hg), the presence of warm hands and bounding pulses modestly increased the probability of septic shock (LR of 2.4 to 2.7). More importantly, the *absence* of warm hands in this study decreased the probability of septic shock (LR = 0.2). In this same study, cardiogenic shock was the likely cause of hypotension if the patient had elevated venous pressure (central venous pressure [CVP] >8 cm H_2O) *and* lung crackles (LR = 56.4). The absence of elevated neck veins decreased the probability of cardiogenic shock (LR = 0.2). In this study, the diagnostic standard for septic and cardiogenic shock was a blinded post hoc review of the patient's clinical course, based in part on subsequent microbiologic and radiographic evidence of infection (septic shock) and echocardiographic evidence of ventricular dysfunction (cardiogenic shock).

C. PULSE PRESSURE CHANGES WITH PASSIVE LEG ELEVATION (HYPOVOLEMIA)

In four studies of 161 critically ill hypotensive patients (most mechanically ventilated), a pulse pressure increase (variably defined as at least 9% to 12%) after passive leg elevation increased the probability of hypovolemic shock, which was

defined as the subsequent response to infusion of 500 cc of intravenous saline (or equivalent fluid, LR = 4.8). The absence of such an increment in pulse pressure was unhelpful (LR = 0.5).

One cause of false-negative results (i.e., the patient is hypovolemic yet lacks a pulse pressure increment of at least 9% to 12%) is intra-abdominal hypertension (i.e., bladder pressure more than 16 mm Hg).[26] Presumably, the high pressures within the abdomen of these patients interfere with the normal increment of central blood volume after leg elevation, thus producing the negative test result.

D. ASSESSMENT OF PERIPHERAL PERFUSION IN THE INTENSIVE CARE UNIT

In patients with critical illness, all three signs of poor peripheral perfusion (cool limbs, prolonged capillary refill times, and mottling of the limbs), alone or in combination, identify patients with reduced cardiac output, worse prognosis, or both. For example, the finding of cool legs in ICU patients increases the probability of low cardiac output (LR = 3.7, EBM Box 70.2), even in the subset of patients with sepsis (LR = 5.2). A capillary refill time of 5 seconds or more predicts major postoperative complications after intra-abdominal surgery (LR = 12.1) and predicts 14-day mortality in patients with sepsis (LR = 4.6). Mottling of the skin over the knees also predicts mortality in patients with sepsis (LR = 13.4), independent of the use of vasopressor medications, and its course over time heralds the patient's outcome (i.e., patients whose mottling diminishes over time have better survival than those whose mottling persists).[31]

Other investigators have focused on combinations of findings. For example, in one study of intubated patients with acute lung injury, the simultaneous presence of capillary refill time of more than 2 seconds,[†] mottling over the knees, and cool limbs increased the probability of low cardiac output (LR = 7.5). In another series of ICU patients, the findings of *either* cool limbs or capillary refill time of 5 seconds or more increased the probability of elevated lactate levels (LR = 2.2) and predicted future progressive multiorgan dysfunction (LR = 2.6).

E. LUNG FINDINGS

In patients hospitalized with exacerbations of chronic obstructive pulmonary disease, the finding of asynchronous breathing (see Chapter 19) accurately predicts subsequent need for intubation or hospital mortality (LR = 3.2). In patients examined after intubation, asymmetric breath sounds are pathognomonic for endobronchial intubation (LR = 18.8), although physical examination *never excludes* this important complication (i.e., symmetric breath sounds do *not* significantly decrease the probability of endobronchial intubation; LR = 0.5). Confirmation of appropriate tube placement by means other than physical examination is always indicated. In patients mechanically ventilated for acute respiratory distress syndrome, the finding of absent vesicular breath sounds increases the probability of underlying pleural effusion (LR = 4.3).

F. NEUROLOGIC FINDINGS

The finding of anisocoria in an unresponsive patient raises concern for the Hutchinson pupil (see Chapter 21), the abnormal larger pupil representing an early

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[†] This study contrasts with other studies of capillary refill by applying only *mild* pressure on the patient's fingertip to elicit the finding, not firm pressure, and by defining the abnormal test as just 2 seconds or more.

EBM BOX 70.2

*Peripheral Perfusion of Intensive Care Unit Patients**

Finding (Reference)†	*Sensitivity (%)*	*Specificity (%)*	**Likelihood Ratio‡ if Finding Is** *Present*	*Absent*
Detecting Low Cardiac Output				
Both legs cool (all patients)[27]	23	94	**3.7**	0.8
Both legs cool (patients with sepsis)[27]	30	94	**5.2**	0.7
Combinations of Hypoperfusion Findings[2]				
0 of 3 findings present	36	24	0.5	—
1 of 3 findings present	52		2.3	—
3 of 3 findings present	12	98	**7.5**	—
Detecting Elevated Arterial Lactate Level				
Limb is cool or capillary refill time ≥5 s[28]	67	69	2.2	0.5
Predicting Multiorgan Dysfunction				
Limb is cool or capillary refill time ≥5 s[28]	77	70	2.6	**0.3**
Predicting Major Postoperative Complications After Intra-abdominal Surgery				
Capillary refill time ≥5 s[29]	79	93	**12.1**	**0.2**
Predicting 14-Day Mortality if Septic Shock				
Capillary refill time ≥5 s[30]	50	89	**4.6**	0.6
Mottling of skin over knees[31]	41	97	**13.4**	0.6

*Diagnostic standard: For *low cardiac output, cardiac index* < 2.5 L/min/m^2 [2] or < 3 L/min/m^2 [27], for *elevated lactate level,* blood lactate >2 mmol/L; for *multiorgan dysfunction,* SOFA score that increases during the first 48 h of hospitalization (SOFA score is the Sequential Organ Failure Assessment, a score tabulating the following variables: P_aO_2/F_iO_2, number of vasoactive pressors being administered, bilirubin, platelet count, Glasgow coma scale, and creatinine or urine output); for *major postoperative complication*, one requiring endoscopy, repeat surgery, general anesthesia, or ICU transfer.[29]

†Definition of findings: For *both legs cool,* either all 4 limbs have cool temperature or legs are cool despite warm arms (patients with known peripheral vascular disease were excluded)[27]; for *combinations of hypoperfusion findings*, there are three: (1) capillary refill time >2 s, (2) skin mottling over the knees, and (3) cool limbs[2]; for all *capillary refill times*, testing performed on the patient's finger or nailbeds; and for *mottling of skin over knees,* mottling extending at least to the mid-thigh level (only light-skinned patients were tested).[31]

‡Likelihood ratio (LR) if finding present = positive LR; LR if finding absent = negative LR.

ICU, Intensive care unit.

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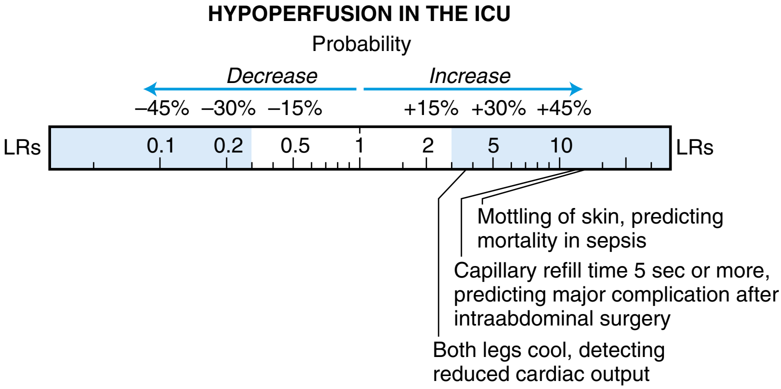

sign of an ipsilateral expanding cerebral mass (LR = 9). A common mimic of this finding in the ICU is the pharmacological pupil, from nebulized bronchodilators, which can be distinguished from the Hutchinson pupil by its lack of response to topical pilocarpine (see Chapter 21).

Neck stiffness raises concern for meningeal irritation, from either purulent secretions (meningitis) or blood (intracranial or subarachnoid hemorrhage). In patients with stroke, the finding of neck stiffness markedly increases probability of intracranial or subarachnoid hemorrhage (LR = 5.4).

The references for this chapter can be found on www.expertconsult.com.

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